THE TWO-COMPONENT NON-PERTURBATIVE POMERON AND THE G-UNIVERSALITY

Basarab NICOLESCU

LPNHE*- LPTPE, Université Pierre et Marie Curie,
4, Place Jussieu, 75252 Paris Cedex 05, France
nicolesc@in2p3.fr

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Abstract

In this communication we present a generalization of the Donnachie-Landshoff model inspired by the recent discovery of a 2-component Pomeron in LLA-QCD by Bartels, Lipatov and Vacca. In particular, we explore a new property, not present in the usual Regge theory - the *G-Universality* - which signifies the independence of one of the Pomeron components on the nature of the initial and final hadrons. The best description of the $\bar{p}p$, pp, $\pi^{\pm}p$, $K^{\pm}p$, $\gamma\gamma$ and γp forward data is obtained when G-universality is imposed. Moreover, the $\ell n^2 s$ behaviour of the hadron amplitude, first established by Heisenberg, is clearly favoured by the data.

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*Unité de Recherche des Universités Paris 6 et Paris 7, Associée au CNRS

The Donnachie-Landshoff model [1] - denoted as Xs^ϵ in the following is very successful in describing σ_T and forward ($t = 0$) ρ data for $\bar{p}p,\ pp,\ \pi^\pm p,\ K^\pm p,\ \gamma\gamma$ and γp scatterings : $\chi^2/dof = 1.020$ for 16 parameters, 383 data points and $\sqrt{s} \geq 9$ GeV [2].

In the present communication I will explore a QCD-inspired generalization of this model. The results are obtained in collaboration with P. Gauron [3].

Recently, Bartels, Lipatov and Vacca [4] discovered the existence of a 2-component Pomeron in LLA. The first component is associated with 2-gluon exchanges and corresponds to an intercept

$$\alpha_P^{2g} \geq 1. \tag{1}$$

The second component is associated with 3-gluon exchanges with $C = +1$ and corresponds to an intercept

$$\alpha_P^{3g} = 1. \tag{2}$$

This last component is exchange-degenerate with the 3-gluon $C = -1$ Odderon. It is therefore useful to explore possible 2-component Pomeron generalizations of the 1-component Xs^ϵ Pomeron

$$\sigma_{AB}(s) = Z_{AB} + X_{AB}(s) + Y_{AB}^+ s^{\alpha_+ - 1} \pm Y_{AB}^- s^{\alpha_- - 1}, \tag{3}$$

where $\sigma_{AB}(s)$ are total cross-sections,

$$\begin{aligned} X_{AB}(s) &= X_{AB} s^{\alpha_P - 1} && (4) \\ &= X_{AB} \ell n\ s && (5) \\ &= X_{AB}\left[\ell n^2\left(\frac{s}{s_0}\right) - \frac{\pi^2}{4}\right], && (6) \end{aligned}$$

and $\alpha_P,\ \alpha_+$ and α_- are Reggeon intercepts ; $Z_{AB},\ X_{AB},\ Y_{AB}^\pm,\ s_0$ are constants. The $+$ sign in front of the Y_{AB}^- term in eq. (3) corresponds to $\{A = \bar{p},\ \pi^-,\ K^-,\ B = p\}$ and the - sign to $\{A = p,\ \pi^+,\ K^+,\ B = p\}$. If $A = \gamma$ in eqs. (3)-(6), then $B = \gamma,\ p$ and $Y_{AB}^- = 0$. An implicit scale factor of 1 $(\mathrm{GeV})^2$ is present in the Reggeon and $\ell n\ s$ terms.

The first model in eqs. (4)-(6) - denoted as $Z + Xs^\epsilon$ in the following - corresponds to a generalized Donnachie - Landshoff approach [5, 6] ; the second - denoted as $Z + X\ell n\ s$ - to the well known dipole approach [7] ; the third - denoted as $Z + X\ell n^2\ s$ - to the Heisenberg - Froissart - Martin form first considered in 1952 by W. Heisenberg [8]. The ρ-parameter is calculated from (3) by using the known $s \to se^{-i\pi/2}$ crossing rule.

We study, in particular, the following properties :

1. The G-universality [5, 9] ("G" from "gluon") expressed by (see eqs. (3)-(6))

$$X_{AB}(s) = X(s), \tag{7}$$

i.e. independence of X_{AB} on A and B ($A,\ B=$ hadrons only), a property not present in the usual Regge theory.

2. The weak exchange-degeneracy

$$\alpha_+ = \alpha_-, \qquad Y^+_{AB} \neq Y^-_{AB}. \tag{8}$$

The results for the simultaneous description of $\bar{p}p$, pp, $\pi^{\pm}p$, $K^{\pm}p$, $\gamma\gamma$ and γp reactions are given in Tables I (fits of σ_T data only) and II (fits of σ_T and ρ data).

Table 1: Results of the fits of σ_T data. The symbol $=$ in the α_+ column means weak exchange-degeneracy ($\alpha_+ = \alpha_-$).

Model	G-Universality		exchange degeneracy		α_+	α_-	N_{par}	χ^2/dof
	Yes	No	Yes	No				
Xs^{ϵ}		x		x	0.66± 0.02	0.45± 0.02	16	0.931
		x	x		=	0.48	15	1.009
$Z+Xs^{\epsilon}$		x		x	0.618±0.021	0.465±0.021	17	0.936
		x	x		=	0.491±0.023	16	0.980
	x			x	0.526±0.029	0.479±0.023	17	0.835
	x		x		=	0.487±0.023	16	0.836
$Z+X\ell n\ s$		x		x	0.826±0.013	0.468±0.022	16	0.865
		x	x		=	0.586±0.019	15	1.281
	x			x	0.658±0.007	0.485±0.022	16	1.066
	x		x		=	0.610±0.016	15	1.286
$Z+X\ell n^2 s$		x		x	0.653±0.026	0.465±0.022	17	0.939
		x	x		=	0.491±0.023	16	0.990
	x			x	0.583±0.077	0.476±0.023	17	0.822
	x		x		=	0.478±0.024	16	0.822
	x		**x**		=	**0.48**	**15**	**0.819**

It can be seen from Tables I-II that the G-universality leads to a clear improvement of the description of all the considered data. Moreover, the

Table 2: Results of the fits of σ_T and ρ data. The symbol = has the same meaning as in Table 1.

Model	G-Universality Yes	G-Universality No	exchange degeneracy Yes	exchange degeneracy No	α_+	α_-	N_{par}	χ^2/dof
Xs^ϵ		x		x	0.66± 0.02	0.45± 0.02	16	1.020
		x	x		=	0.48	15	1.320
$Z + Xs^\epsilon$		x		x	0.641±0.012	0.440±0.015	17	1.024
		x	x		=	0.494±0.013	16	1.203
	x			x	0.602±0.014	0.458±0.016	17	0.986
	x		x		=	0.500±0.013	16	1.092
$Z + X\ell n\ s$		x		x	0.816±0.001	0.450±0.012	16	0.941
		x	x		=	0.569±0.001	15	1.769
	x			x	0.691±0.005	0.465±0.015	16	1.250
	x		x		=	0.592±0.008	15	1.944
$Z + X\ell n^2 s$		x		x	0.651±0.017	0.442±0.016	17	1.015
		x	x		=	0.475±0.014	16	1.142
	x			**x**	**0.552± 0.048**	**0.453± 0.017**	**17**	**0.927**
	x		x		=	0.457±0.015	16	0.933

G-universality leads to a mild violation of the weak exchange-degeneracy ($\alpha_+ - \alpha_- \simeq 0.1$), in constant with the non-universality cases. These two independent features could hardly be considered as numerical accidents. It is therefore important to explore the validity of the 2-component G-universal Pomeron in all the other (non-forward) existing data.

A remarkable result is the fact that the forward data clearly favour the maximal Heisenberg-Froissart-Martin $\ell n^2 s$ behaviour of the hadron scattering amplitude [8] : the absolute minimum of χ^2/dof is precisely obtained for the G-universal $\ell n^2 s$ form of the amplitude. Our χ^2/dof is better than that given in the last edition of "Review of Particle Physics" [2].

Let us also note that the dipole model, corresponding to a $\ell n\ s$ behaviour of the scattering amplitude, has a serious pathology : the first component of the Pomeron Z_{AB} has a *negative* contribution to the total cross-sections. Therefore this $\ell n\ s$ fit has to be dismissed. The

above pathological feature of the $\ell n\ s$ model was already remarked in J.R. Cudell et al. [2], but it was omitted from the "Review of Particle Physics" [2].

The theoretical and numerical details will be presented elsewhere [3].

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